HEAT ENGINES

A Heat engine is a thermal prime mover that converts the chemical energy of a fuel in toheat energy by combustion of fuel and utilizes this energy to perform mechanical work. Heat engines are broadly classified into two categories

1) External Combustion Engines (E.C. Engines) : In these engines, combustion of fuel takesplace outside the engine cylinder. Ex: Steam engines, Steam turbines, closed cycle gas engine, etc. The EC engines are mainly used for large electric power generators.

2) Internal Combustion Engines (I.C. Engines): In IC Engines, the combustion of fuel takes place inside the engine cylinder. Ex: Petrol Engines, Diesel Engines, Gas Engines, etc. IC Engines are mainly used for transport vehicles.

Classification of I C Engines

i) According to the type of fuel used

1. Petrol Engines
2. Diesel Engines
3. Gas engines
4. Bi-Fuel Engines

ii) According to the number of strokes per cycle

1. Four stroke engine
2. Two stroke engine

iii) According to the method of ignition

1. Spark Ignition engine
2. Compression Ignition engine

iv) According to the cycle of working

1. Otto Cycle engine (Constant Volume cycle engine)
2. Diesel Cycle engine (Constant Pressure cycle engine)
3. Dual Combustion cycle engine

v) According to the number of cylinders

1. Single cylinder engine
2. Multi cylinder engine

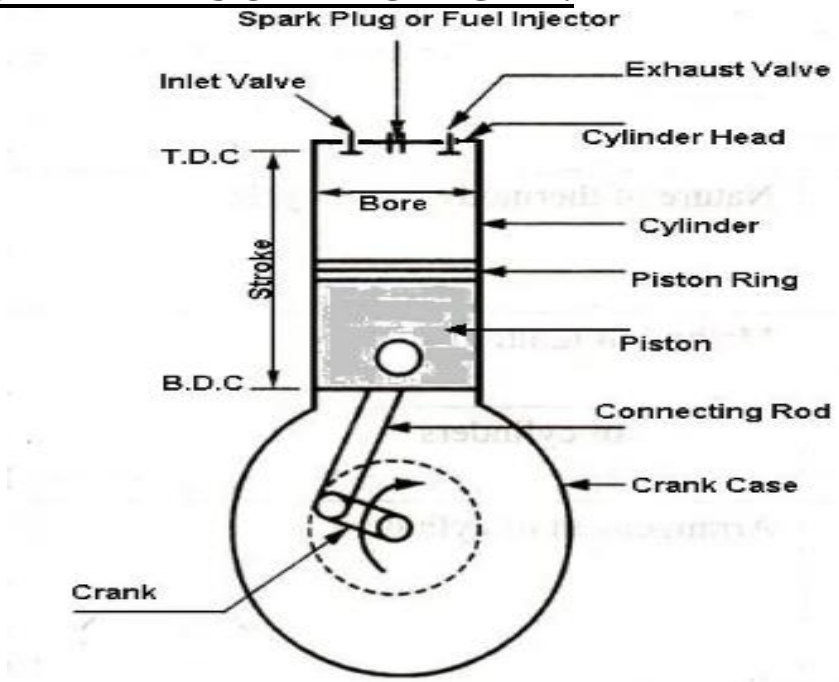
vi) According to the method of cooling

1. Air cooled engine
2. Water cooled engine

➢ TECHNICAL TERMS RELATED TO I C ENGINES:

1. **Bore:** It is the inside diameter of engine cylinder
2. **Stroke:** It is the linear distance traveled by the piston from TDC to BDC or from BDC to TDC.
3. **Swept Volume (Vs):** It is the Volume swept by the piston as it moves between TDC and BDC.
4. **Clearance Volume(Vc):** It is volume of the cylinder above the top of the piston when pistonis at TDC.
5. **Compression Ratio :** It is ratio of the total cylinder volume to the clearance volume
6. Compression Ratio = Vs + Vc / Vc
7. **Piston Speed:** The average linear speed of the piston is called piston speed and is given byS = 2 l. N where l- stroke and N –speed of the engine.

➢ PRINCIPAL PARTS OF AN IC ENGINE:



1) Cylinder: The heart of the engine is the cylinder in which the fuel is burnt and the power isgenerated. Its function is to contain the working fluid under pressure and to guide the piston while reciprocating inside the cylinder.

The cylinder is usually made of Grey Cast Iron or steel alloys in order to withstand the high pressure and temperature during combustion.

2) Cylinder Head: The top end of the cylinder is closed by a removable cylinder head. The cylinder head consists of two valves i.e. inlet and outlet valves. It is usually made of Cast iron oralloys of cast iron

3) Piston: It is close fitting hollow cylindrical plunger moving to and fro in the cylinder. The main function of the piston is to compress the charge during compression stroke and to receive the impulse produced by the combustion of the fuel and to transmit the energy to the crankshaft.

4) Piston rings: These are the metallic rings inserted into the circumferential grooves provided at the top end of the piston. These rings maintain a gas tight joint between the piston and cylinderwhile the piston is reciprocating in the cylinder. They are two sets of piston rings. One set is called compression rings which press hard against the cylinder walls forming a tight seal between piston and the cylinder. This prevents the high pressure gases from escaping into the crankcase. Another set of rings called oil rings which are used to extract the lubricating oil from the cylinder walls and to send it back to the oil sump through holes provided in the piston.

5) Connecting rod: It forms a link between piston and the crankshaft. It converts the linear motion of the piston into rotary motion of the crankshaft.

6) Crank and crankshaft: The crank is a lever that is connected to the end of theconnecting rod by a pin joint with its other end connected rigidly to a shaft called crankshaft. It rotates about the axis of the crankshaft and causes the connecting rod to oscillate.The power required for any useful purpose is taken from the crankshaft.

7) Fly wheel: It is heavy wheel mounted on the crankshaft of the engine to maintain uniform rotation of the crankshaft. It is used as an energy saving device. It stores energy received during power stroke and supplies the same during other strokes.

8) Crank case: It is lower part of the engine serving as an enclosure for the crankshaft and alsoas a sump for the lubricating oil

9) Valves: These are the control devices that allow the air/fuel to enter into the cylinder and also discharge the burnt gases to the atmosphere. The inlet and outlet valves serve these purposes. The valves are actuated by means of springs, cam and lever mechanisms and are made to open and closed so that the charge enters/discharges at the right time

➢ WORKING PRINCIPLE OF FOUR STROKE PETROL ENGINE CONSTANT VOLUME CYCLE ENGINE)

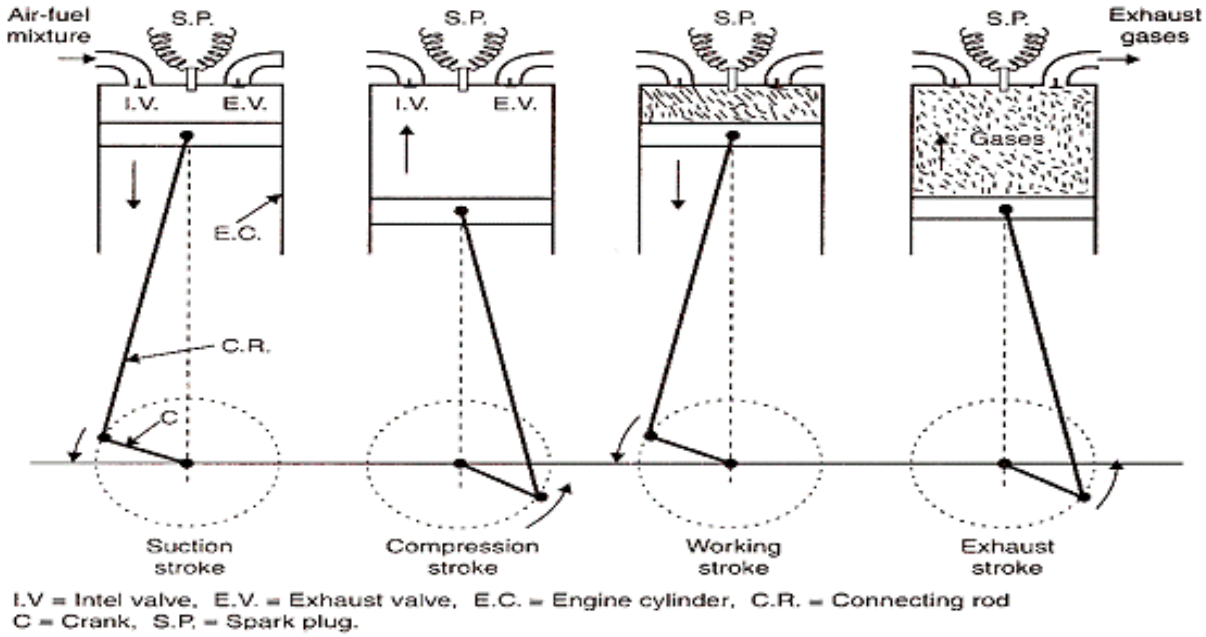


Fig: Four stroke petrol engine

It is also known as Otto cycle or constant volume cycle engine. It requires four strokes ofthe piston to complete one cycle of operations in the engine cylinder. The four strokes are as follows:

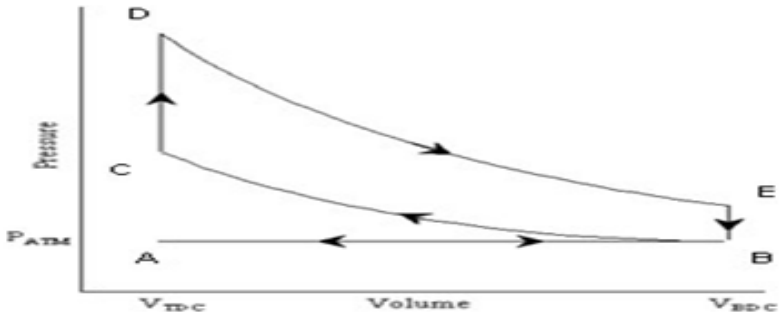


Fig: P-V Diagram

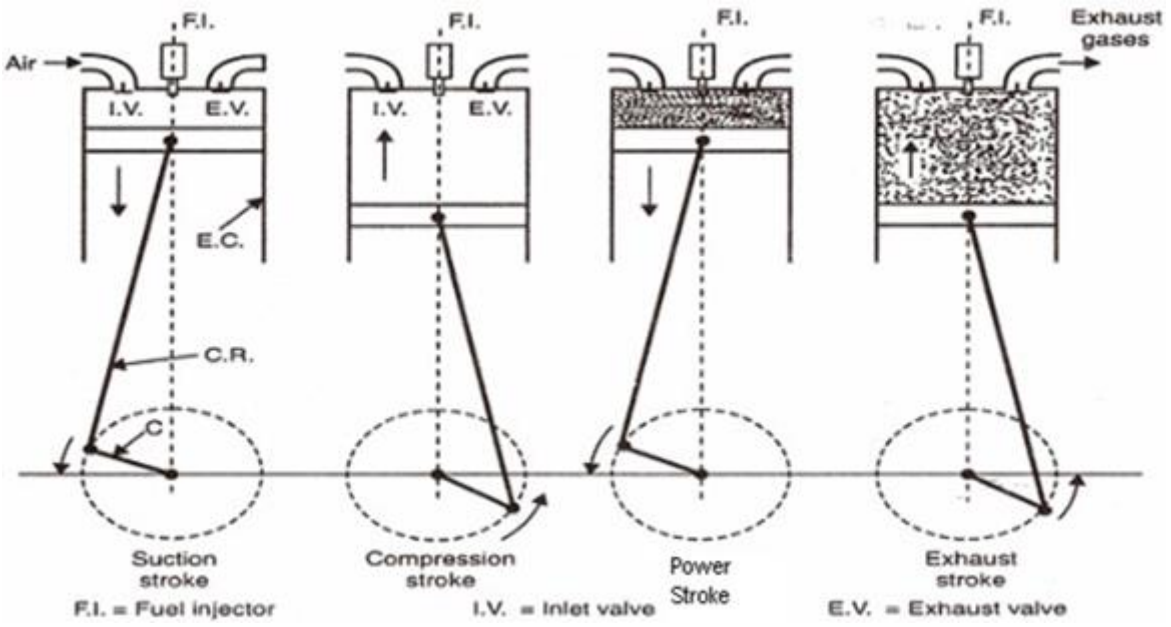
1) **Suction stroke**: In this stroke, the inlet valve opens and the fresh charge (petrol and air mixture from carburetor) is sucked into the engine cylinder as the piston moves from TDC to BDC. It continues till the piston reaches BDC. During this travel of the piston the crankshaft revolves by half rotation. Because of the pressure difference between the atmosphere and the inside of the engine cylinder, petrol-air mixture will be drawn into the cylinder from the carburetor. At the end of this stroke, the cylinder will be completely filled with petrol-air mixture and inlet valve is closed.

2) **Compression Stroke**: In this stroke, both inlet and outlet valves are closed and charge is compressed as the piston moves from BDC to TDC. As a result of compression, pressure andtemperature of the charge increases considerably. This completes one revolution of the crankshaft. Shortly before the piston reaches the TDC during this stroke, the charge is ignited with thehelp of a spark plug.

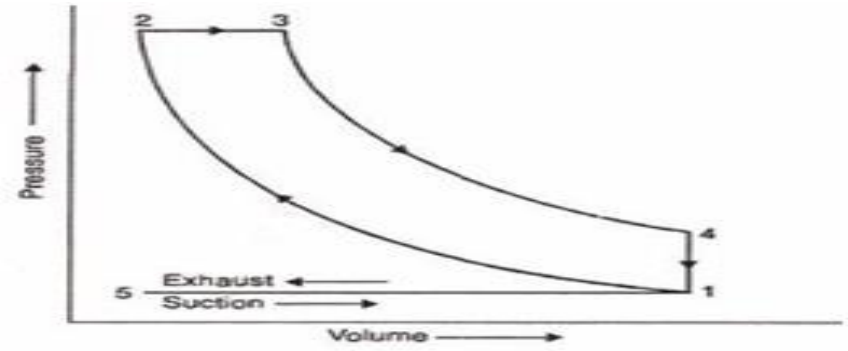
3) **Power Stroke (Working stroke or Expansion stroke)**: During this stroke, both the valves are closed and because of the combustion of charge, the burnt gases expand. Due to this expansion, the hot gases exert pressure on the piston and as a result, the piston is pushed from TDC to BDC. The power impulse is transmitted down through the piston to the crankshaft. This causes the crankshaft to rotate at high speeds. Thus, work is obtained in this stroke. At the end ofthis stroke, the exhaust valve opens which will release the burnt gases to the atmosphere.

4) **Exhaust Stroke**: In this stroke, the exhaust valve is open as piston moves from BDC to TDC. This movement of piston pushes out the burnt gases from the cylinder to the atmosphere. This completed one cycle of operation and the engine is ready for the next cycle.

➢ WORKING PRINCIPLE OF FOUR STROKES DIESEL ENGINE (CONSTANT PRESSURE CYCLE):



4 Stroke Diesel Engine



P-V Diagram

Air alone is compressed during the compression stroke and at end of this stroke, the fuelinjector injects fuel into the hot compressed air. The fuel is then ignited as it comes in contact with the hot compressed air. Hence these engines are called compression ignition engines. The working principle of 4 stroke diesel engine is based on Diesel cycle, hence they are called diesel cycle or constant pressure cycle engines.

The four different strokes of the 4 stroke diesel cycle isas under:

i) Suction Stroke: During this stroke, the piston moves from TDC to BDC. The inlet valve opens and exhaust valve will be closed. The downward movement of the piston creates a suction in the cylinder and as a result atmospheric air from the air filter is drawn into the engine cylinder through the inlet valve. When the piston reaches BDC, the suction stroke ends with closure of theinlet valve.

ii) Compression Stroke: During this stroke, the piston moves from BDC to TDC and both the inlet and exhaust valves are closed. As the piston moves upwards, the air inside the engine cylinder is compressed to high pressure and temperature. The compression process is adiabatic innature and the compression ratio will be from 15:1 to 22:1. At the end of this stroke, the fuel is injected into the engine cylinder in the form of fine sprays by a fuel injector. Combustion of fuel takes place at constant pressure.

iii) Power Stroke: During this stroke, both inlet and exhaust valves remain closed. Due to thecombustion of fuel, the burnt gases expand and exert a large force on the piston.

Due to this, the piston is pushed from TDC to BDC. The power impulse is transmitteddown through the piston to the crankshaft through the connecting rod. This causes thecrankshaft to rotate at high speeds. Thus power is obtained during this stroke. The expansion gases is adiabatic in nature and when the piston reaches BDC the exhaust valve opens. A part of the burnt gases escapes through the exhaust valve due to their expansion. The drop in pressure is at constant volume.

iv) Exhaust Stroke: During this stroke, the piston moves from BDC to TDC and the inlet valve will be closed and exhaust valve will be opened. As the piston moves upwards, it forces the burntgases out of the engine cylinder. When the piston reaches TDC, the exhaust valve close and the next cycle of suction stroke begins. Thus in this engine, four operations are completed in two revolutions of the crank shaft or 4strokes of the piston and the power is obtained during only in power stroke i.e. one power stroke for two revolutions of the crankshaft.

➢ COMPARISON OF PETROL ENGINE AND DIESEL ENGINE:

S.No	Petrol Engine	Diesel Engine
1	Follows Petrol Cycle	Follows Diesel Cycle
2	Petrol is used as Fuel	Diesel is used as Fuel
3	Ignition is by Spark ignition	Ignition is by Compression ignition
4	Fuel is supplied to the cylinder by Carburetor	Fuel is supplied to the cylinder by Fuelinjector
5	Running cost is more	Running cost is less
6	Low compression ratio(6:1 to 8:1)	High compression ratio(15:1 to 22:1)
7	Noise level is less	Noise level is more
8	Can easily be started in cold condition	Difficult to start in cold condition
9	Initial cost is less	Initial cost is more
10	Engine weight is less	Engine weight is more

➢ PARAMETERS INVOVLED IN IC ENGINES:

The job of an internal combustion engine is to convert heat energy into mechanical energy. Practically it means that an IC engine of any type produce mechanical work in the form of a rotating shaft giving some torque at some value of r.p.m by continuously burning of fuel. Performances of IC engine means that how will it complete the above mentioned job. It can be measured or compared only in terms of certain parameters as mentioned in this chapter. These parameters are called performance parameters.

Indicated Power (IP)

The total power developed by combustion of fuel in the combustion chamber is called Indicated Power (IP). It can be calculated as:

$$I.P = \frac{nP_{m_i}.L\,A\,N\,K\times 10}{6}\ kW$$

Where n = number of cylinders

P_{mi} = Indicated mean effective pressure, (bars)

L = Length of stroke, (m)

A = Area of piston, (m^2)

K = for 4 stroke engine

= 1 for 2 stroke engine

Brake Power (BP)

The power available at an engine's output shaft is called its brake power. It is the power which can be positively used against resistive force or braking force of the application for which engine is being used. It can be calculated as

$$B.P = \frac{2\pi NT}{60\times1000}\,kW$$

Where N = engine speed in rpm

T = Torque at output shaft in N-m.

Mechanical efficiency

It is the ratio of brake power to the indicated power of an IC Engine.

$$\eta_{mean} = \frac{B.P}{I.P}$$

Specific fuel consumption

It is the mass of fuel consumed in kg/hour per kW of power developed by engine.

$$S.f.C = \frac{m_f}{B.P.}\,kg/kWhour$$

Thermal efficiency

It is the ratio of work done or power developed by an engine to the rate of chemical energy or heat supplied by burning of fuel in the engine. It can be based on indicated power or brake power and accordingly can be specified as

Indicated Thermal Efficiency $\eta_{th}(1) = \frac{I.P}{m_f \times C}$

Brake Thermal Efficiency $\eta_{th}(B) = \frac{B.P}{m_f \times C}$

Where,

m_f = Rate of fuel consumed (kg / sec)

C = calorific value of fuel (kJ/ kg)

I.P. = Indicated power (kW)

B.P. = Brake power (kW)

APPLICATIONS OF IC ENGINES:

Following are the application of ic engine:

1. IC engines are used in Road vehicles like scooters, motorcycles, buses etc.
2. It is also used in Aircraft.
3. IC engine is commonly used in Motorboats.
4. IC engine has great application in small machines, such as lawnmowers, chainsaws, and portable engine-generators.

➢ NUMERICAL ON I C ENGINES:

1)A 4-stroke engine has a piston diameter 250 mm and stroke 400 mm. The mean effective pressure is 4 bar and speed is 500 rpm. Find the Indicated horse power.
Solution : Data Given:
Stroke = 4 Stroke
Piston diameter (d) = 250mm = 0.250 m
A(Area of cylinder) = 3-14 *(0.252) / 4 = 0.049 m2
Stroke = 400 mm = 0.400 m
Mean effective pressure = 4 bar=4 Pascals=4 *105 N / m2
N= 500 rpm: Since 4- stroke engine,N=N/2 rpm
IHP = ?
n=No.of Cylindres=1
IHP = npmLAN (10/6) K W
= 1 * 4 * 0.4 *0.049*(500*1/2)(10/6)
=32.67 kw

2) The following data refers to a 4-stroke engine:
Cylinder diameter : 200mm, Stroke= 300 mm, Speed= 300 rpm, mean effective pressure= 6 bar.
Find out the IHP
Solution : Answer =14.13 kw

3) The following observations were recorded during a test on a 4-stroke engine.Bore:25 cm,stroke:40 cm, speed :250 rpm. Mean effective pressure :6 bar. Find out the IHP

Solution:
Data given:
Stroke=4 stroke
Bore(Piston diameter)=25 cm =0.25 m
A=3.14*(0.252) = 0.0490 m2
Stroke=40cm=0.4m
Pm=6 bar
N=250.
IHP=n.pmLAN (10/6*2) (Because 4 stroke engine)
1*6*0.4*0.049*250*10/2*6
=24.5 kw

4) A four cylinder , 4-stroke I C Engine ,rpm:3000 rpm, Mean effective pressure : 12.575 bar, Cylinder diameter: 75mm , stroke 90: mm. Find IHP.
Solution:
Data given:
Stroke=4
N=No. of cylinders=4
N=3000 rpm
Pm=12.575 N/m2
D=Cyl diameter=75 mm=0.075m.
A = 3.14*(0.075)2
/4=0.00441m2
L=Stroke=90mm=0.09 m
IHP=?
IHP=n.Pm.L A N(10/6)/2
=4*12.575 *0.09*0.00441*3000*(10?6)/2
= 50 kw

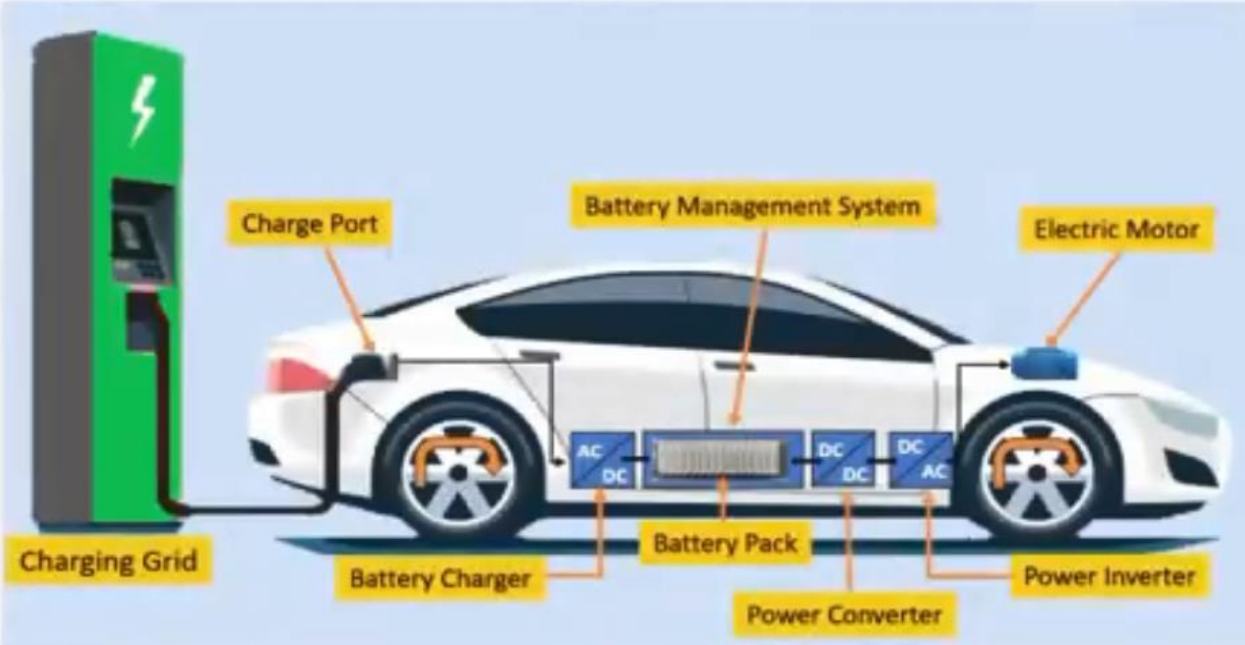
ELECTRIC VEHICLES

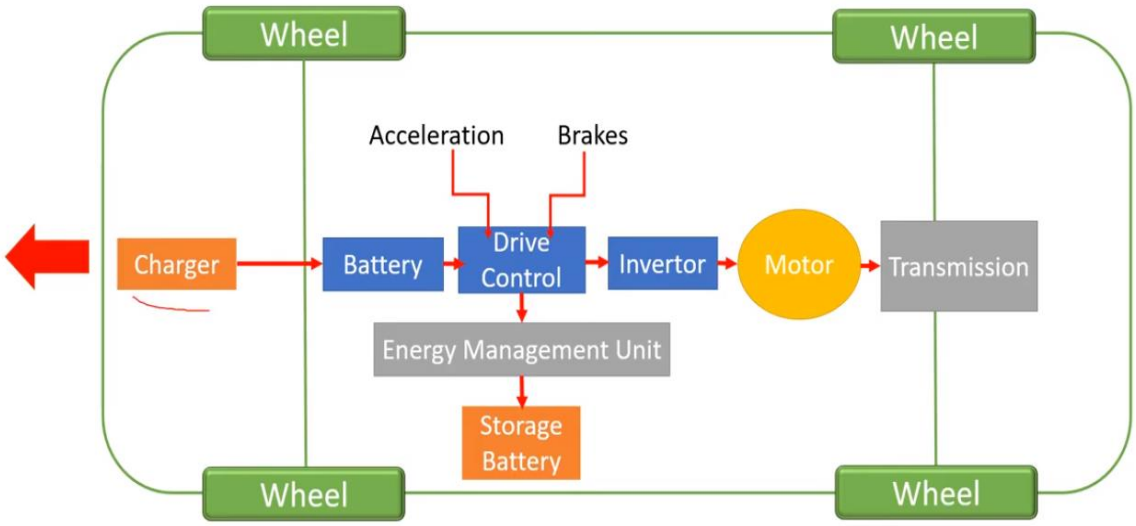
Introduction

An electric vehicle, also called an electric drive vehicle, uses one or more electric motors or traction motors for propulsion. An electric vehicle may be powered through a collector system by electricity from off-vehicle sources, or may be self-contained with a battery, solar panels or a generator to convert fuel to electricity.

EVs include road and rail vehicles, surface and underwater vessels, electric aircraft and electric spacecraft.

Components of Electric Vehicles:





1. **Charge port**: Connects to external power grid and charges the battery pack. It is present in Battery and plug in hybrid cars.

2. Battery charger:

- Converts AC received through Charge port to DC. To store in battery pack.
- Battery pack: it is the main source in case of electric vehicle. It stores electrical energy in the form of DC current. It is the set of any number of individual battery cells.
- It is configured in series, Parallel and combination.
- Li-ion battery is commonly used.

3. **Battery management System**:

- It is an electronic system that manages the battery pack.
- By protecting the battery from operating outside its safe area.
- Its functions like- Monitoring its state
  -Reporting that data
  -Controlling its environment
  -Cell-balancing.

4. Power converter-

- It is a DC/DC converter.
- It takes the voltage from DC source and converts DC voltage level into another DC voltage level. Used to increase or decrease voltage level.

5. **Power Inverter:**

- it converts DC on the battery into AC.
- It is used by electric motor to drive the wheels.
- During regenerative braking, AC is converted to DC and then used to recharge the battery.

6. **Electric motor:** It converts electric energy to Mechanical energy to drive the vehicles.

ADVANTAGES OF ELECTRIC VEHICLES

1. **Environment-friendly**: Electric vehicles do not use fuels for combustion and hence there is no emission or exhaust of gasses. Vehicles using fossil fuels are large contributors to harmful gas build-up in the environment so the use of an electric car can help contribute to a cleaner atmosphere.
2. **Renewable energy source**: Electric vehicles run on electricity that is renewable whereas conventional cars work on the burning of fossil fuels that exhaust the fossil-fuel reserves on earth.
3. **Cost-effective**: Electricity is much cheaper than fuels like petrol and diesel which suffer a frequent price hike. The recharging of batteries is cost-effective if solar power is used at home.
4. **Low maintenance**: Electric vehicles have fewer moving parts so wear and tear is less as compared to conventional auto parts. Repair work is also simple and less expensive relative to combustion engines.
5. **Less noise and smoother motion**: Electric vehicles give a much smoother driving experience. The absence of rapidly moving parts makes them much quiet with low sound generation.
6. **Government support**: Governments in various countries have offered tax credits as an incentive to encourage people to use electric vehicles as a go-green initiative.

DISADVANTAGES OF ELECTRIC VEHICLES

1. **High initial cost**: Electric vehicles are still very expensive and many consumers consider them not as affordable as conventional vehicles.
2. **Charging station limitations**: People who need to drive long distances are worried about getting suitable charging stations midway which is not available everywhere.
3. **Recharging takes time**: Unlike conventional cars that require a few minutes for refilling fuel, recharging of the electric vehicle takes much more time which is generally a few hours.
4. **Limited choices**: Presently there aren't too many electric models of cars available to choose from when it comes to the looks, designs, or customized versions.
5. **Less driving range**: The driving range of the electric vehicles is found to be less as compared to conventional vehicles. Electric vehicles can be suitable for day-to-day travel but can be problematic for a long-distance journey

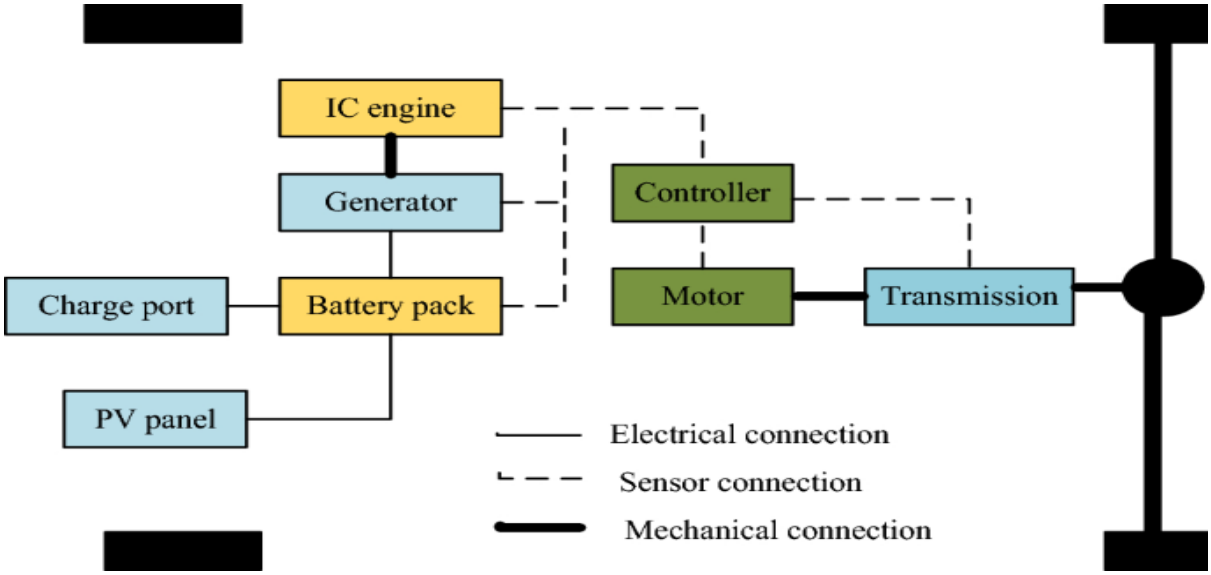
HYBRID ELECTRIC VEHCILES:

A hybrid vehicle is a vehicle that uses two or more distinct power sources to run. Ordinarily, the vehicle which we use daily derives the power from only one source i.e. an IC engine which runs on Petrol or Diesel.

But, in case of a hybrid vehicle, in addition to the IC engine, there is an electric battery which is capable of supplying power to run the vehicle. Hence, such vehicles are called 'Hybrid vehicles'.An internal combustion engine used in a hybrid vehicle may either run on Petrol or Diesel fuel.

For example, a truck that uses a diesel to drive a generator, which in turn drives several electrical motors for all-wheel drive, is not a hybrid. But if the truck has electrical energy storage to provide a second mode, which is electrical assists, then it is a **hybrid Vehicle**. These two power sources may be paired in series, meaning that the gas engine charges the batteries of an electric motor that powers the car, or in parallel, with both mechanisms driving the car directly.

Main components of a Hybrid vehicle:



1. An internal combustion engine (i.e. Petrol engine / Diesel engine): In most of the hybridvehicles, IC engine acts as the main source of power.
2. Electric motor: It transforms the electric energy stored in a battery into mechanical energy i.e. it drives wheels with the help of electricity stored in a battery.
3. Electric battery: Its function is to store electric energy and supply it whenever necessary.

4. Inverter: Electricity stored in an electric battery is in the form of Direct Current (DC) while the majority of the motors used in the present day hybrid vehicles require Alternating Current (AC) to run. So, an Inverter performs the function of converting the DC from the battery to AC for the motor.
5. Electric Generator (Exclusive for series & series-parallel hybrids): The function of a generator is to produce electricity when driven by an external power source. Series hybrids use this component where an IC engine drives a generator to produce electricity which then charges the battery.
6. Control Module: It is the most important component of the hybrid vehicle. It controls the entire operation of the vehicle by synchronizing all the power sources employed.

ADVANTAGES OF HYBRID ELECTRIC VEHICLES

The advantages of hybrid vehicles are listed below:

1. **Idle-off:** Adding a supplementary electric motor offers the vehicle with "idle-off" a sizable number of advantages. In other words, the electric vehicle can move even the primary engine offs. As a result, batteries are used to power amenities like radios and air conditioning.

2. Quick Acceleration: When extra power is needed, the hybrid car's tools enable it to switch from an electric motor to the main engine.

When accelerating hard, this happens more frequently.

3. **Power Support:** One of the primary benefits of hybrid automobiles is the possibility to lower the size of the main engine, which increases fuel economy.

Many hybrid cars use electric motors to start up and accelerate slows until they reach higher speeds. Then, they use gasoline engines to increase fuel efficiency.

4. Regenerative Braking: One of the most acceptable benefits of hybrid vehicles is this. Kinetic energy may be converted into electric energy during regenerative braking, which recharges the battery system.

The wheels of the car drive forward to power the engine when it is in reverse. This assists in lowering the vehicle's speed while simultaneously recharging.

DISADVANTAGES OF HYBRID ELECTRIC VEHICLES

Here are some disadvantages of hybrid electric vehicles:

1. **Low Efficiency:** The major goal of a hybrid vehicle is to enhance its fuel economy or mobility; it may not accelerate as quickly as a vehicle powered by an internal combustion

engine.

2. Expensive to Purchase: Despite the efforts by manufacturers to close the price difference between hybrids and regular vehicles, hybrids still command higher prices.

3. Higher Maintenance: Since hybrid vehicles are powered by two different sets of engines and have many mechanical components, maintenance costs are still extremely high